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## EXERCISES.

### 93

FIND the radius of the circle inscribed in the evolute of an ellipse and the ratio in which each point of contact divides the quadrant on which it lies.

[*R. H. Graves.*]

### 94

$O$ is the centre of the circumscribed circle of $ABC$, and $D$, $E$, $F$ the middle points of its sides. Show that

$$OD^2 + OE^2 + OF^2 = 2R'(2R' - r'),$$

where $R', r'$ are the radii of the circumscribed and inscribed circles of the triangle of the feet of the altitudes. [*R. D. Bohannan.*]

### 95

IN exercise 65 let $k, l$ be the lengths of the perpendiculars $CD$, $CE$ drawn at right angles to $CA$, $CB$ to meet the base in $D$, $E$. Show that

$$\frac{m}{c} = \frac{k}{a} \cdot \frac{l}{b}.$$

[*Ormond Stone.*]

### 96

GIVEN on the ground a circular curve of known radius intersecting a given straight line at a given point, and inclined to it at that point at a given angle; it is required to determine the radius of a second circular arc which shall be tangent both to the given curve and to the given line at another given point.

[*Calvin Whiteley.*]

### 97

IN the triangle $ABC$ two lines drawn from $C$ trisect the side $AB$. Given $c$, $C$, and the angle $\varphi$ between the trisecants; to solve the triangle.

[*Marcus Baker.*]

### 98

THE eccentric anomalies of three points on an ellipse are $p_1, p_2, p_3$. Show that the area of their triangle is

$$\Delta = 2ab \sin\frac{p_2 - p_3}{2} \sin\frac{p_3 - p_1}{2} \sin\frac{p_1 - p_2}{2};$$

the centre of its circumscribing circle

$$x = +\frac{c^2}{a} \cos\frac{p_2 + p_3}{2} \cos\frac{p_3 + p_1}{2} \cos\frac{p_1 + p_2}{2},$$

$$y = -\frac{c^2}{b} \sin\frac{p_2 + p_3}{2} \sin\frac{p_3 + p_1}{2} \sin\frac{p_1 + p_2}{2};$$

and hence show that the centre of curvature of the ellipse at $(x, y)$ is

$$X = +\frac{c^2x^3}{a^4}, \quad Y = -\frac{c^2y^3}{b^4}. \qquad [\textit{Wm. M. Thornton.}]$$

## 99

FROM a full cask of wine a quantity is taken out at random and the cask filled with water, and then a quantity of the mixture is taken out at random and the cask again filled with water. What is the probability that the cask now contains more wine than water? [*Artemas Martin.*]

SELECTED.

## 100

THE points $O$, $O'$ defined by the equations in trilinears

$$a\alpha : b\beta : c\gamma = c^2a^2 : a^2b^2 : b^2c^2,$$
$$a\alpha : b\beta : c\gamma = a^2b^2 : b^2c^2 : c^2a^2,$$

are called the Brocard points. The angles $OCA$, $OAB$, $OBC$, $O'BA$, $O'CB$, $O'AC$ are called the Brocard angles.

1. Show that the Brocard angles are all equal each to

$$\cot^{-1}[\cot A + \cot B + \cot C].$$

2. Find the equation to the Brocard line $OO'$.

3. Find the equation to the Brocard circle through $O$, $O'$ and the centre of the circumscribed circle.

4. Given the base $BC$ and the Brocard angle of a triangle, find the locus of the vertex.

5. Show that the medians bisect the angles between the bisectrices of the angles of $ABC$ and the "symmedian lines"

$$\frac{a}{a} = \frac{\beta}{b} = \frac{\gamma}{c}.$$

6. Show that the Brocard circle contains the symmedian point.

## 101

EXPRESS in terms of $\sin^{-1}x$ and $\sin^{-1}y$

$$\tan^{-1}\frac{x+y}{\sqrt{(1-x^2)}+\sqrt{(1-y^2)}}.$$

## 102

FIND the relation connecting $x, y, z$ when

$$\cot^{-1}(x+y+z-xyz) = \cot^{-1}x + \cot^{-1}y + \cot^{-1}z.$$

## 103

INTO a conical wine glass a spherical ball is dropped. Find the ratio of the concealed surfaces of the ball and the inside of the glass.